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# Brachial Plexus Nerve Block with CT Guidance for Regional Pain Management: Initial Results<sup>1</sup>

Brachial plexus nerve blocks are performed to treat patients with chronic pain referable to the brachial plexus. The needle insertion and trajectory are based on palpation of surface landmarks. Occasionally, the surface landmarks are difficult to identify owing to body habitus or anatomic alterations secondary to surgery or radiation therapy. The intent of this manuscript is to describe a technique for brachial plexus block guided with computed tomography and to report our initial results for regional pain management.

The role of imaging-guided therapy for delivery of regional anesthesia for pain management and treatment of patients with brachial plexopathies is an important area that has received little attention (1–7). Causes of such chronic brachial plexopathies include stenosis of the cervical neural foramina that causes a mononeuropathy, neoplastic invasion of the brachial plexus by Pancoast tumor or metastases, and plexopathies that result from prior treatment. Treatment for such patients often includes percutaneous nerve root block. The site of needle insertion is based on palpation of surface anatomic landmarks (8–12). At times, the normal surface landmarks may be difficult to palpate in patients who have short thick necks or have undergone surgery or radiation therapy. This often results in an inability to properly localize the anatomic site for needle insertion and may result in incorrect needle placement. The result is often inadequate pain control.

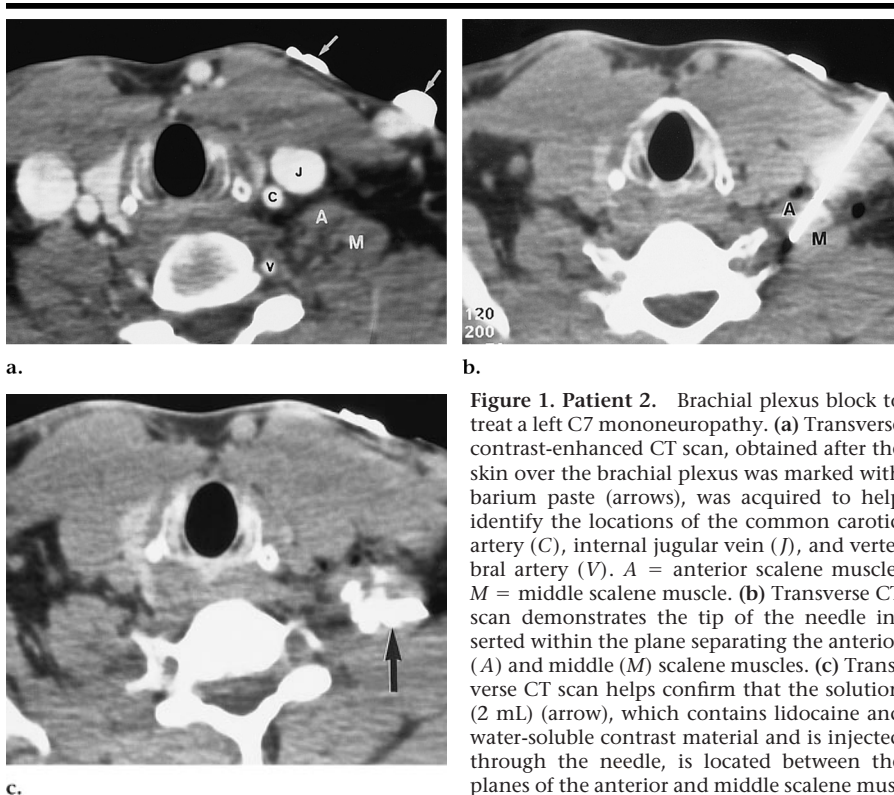
Imaging guidance may be used to guide percutaneous nerve root block by

helping to localize the optimal site of needle insertion and identify the extent of analgesic distribution that would provide optimum pain relief. The purpose of this article is to describe a technique for brachial plexus block guided with computed tomography (CT) and report our initial results for regional pain management in patients with chronic pain referable to the brachial plexus and surface landmarks that cannot be palpated.

## Materials and Methods

We performed six CT-guided brachial plexus block procedures in five patients (three men and two women; age range, 33–72 years; mean age, 52.2 years). All patients had chronic neuropathic pain that was believed by members of the pain management center of the department of anesthesiology at our institution to originate from the brachial plexus. Brachial plexus blocks are routinely performed in our anesthesiology clinic on the basis of surface landmarks. Because the surface landmarks were difficult to palpate on clinical examination in these five patients, our pain management colleagues requested that we perform the procedures with imaging guidance.

Patients 2 and 3 had cervical mononeuropathies, and the blocks were performed as diagnostic procedures prior to foraminotomy to help confirm that the pain was originating from nerve root components of the brachial plexus (Fig 1). One procedure was performed in patient 5, who had recurrent Pancoast tumor (Fig 2); he underwent a second procedure 6 weeks after the original diagnostic block to duplicate the pain relief received from the initial procedure. Patient 1 experienced chronic pain following a modified radical mastectomy for breast carcinoma, and postmastectomy



**Figure 1. Patient 2.** Brachial plexus block to treat a left C7 mononeuropathy. (a) Transverse contrast-enhanced CT scan, obtained after the skin over the brachial plexus was marked with barium paste (arrows), was acquired to help identify the locations of the common carotid artery (C), internal jugular vein (J), and vertebral artery (V). A = anterior scalene muscle, M = middle scalene muscle. (b) Transverse CT scan demonstrates the tip of the needle inserted within the plane separating the anterior (A) and middle (M) scalene muscles. (c) Transverse CT scan helps confirm that the solution (2 mL) (arrow), which contains lidocaine and water-soluble contrast material and is injected through the needle, is located between the planes of the anterior and middle scalene muscles and thereby must involve the supraclavicular brachial plexus. The patient experienced complete pain relief immediately after the injection.

syndrome was diagnosed. Patient 4 underwent phenol neurolysis of the brachial plexus to treat intractable pain from metastatic carcinoma encasing the retroclavicular portion of the brachial plexus.

In patients with intractable pain at our institution, the majority (80%–90%) of brachial plexus nerve root blocks are performed without the use of imaging guidance. Indications for the use of CT guidance are (a) inability to palpate normal surface landmarks owing to body habitus or anatomic alterations due to tumor infiltration or fibrotic changes from previous radiation therapy, (b) prior unsuccessful block, and (c) neurolysis of the brachial plexus. Previous investigators (13) have stated that the success of a local anesthetic block may be adversely affected by anatomic distortion caused by radiation therapy or surgery.

Figure 3 is a schematic of our approach with CT guidance. The patient is placed on the CT table in the supine position. An attempt is made to rotate the patient so that the side of interest is elevated approximately 30° above the plane of the table, and every attempt is made to retract the patient's arm inferiorly. This positioning was performed to make the angle of needle insertion more perpendicular to the plane of the table, but it was not always possible because the pa-

tient's pain was exacerbated. The head was turned away from the area of interest. The skin was marked with barium paste and contrast material was injected (100 mL, 2 mL/sec) prior to helical CT (Somatom Plus 4; Siemens Medical Systems, Erlangen, Germany) (3-mm-thick contiguous sections) from the hyoid bone to the thoracic inlet (Fig 1).

An appropriate site of entry was then chosen by first identifying the anterior and middle scalene muscles (Fig 1), which denote the plane of the supraclavicular portion of the brachial plexus. For standard brachial plexus block, the site of insertion was usually located at the inferior half of the cricoid cartilage to place the region of insertion between the C7–C8 nerve roots. The site of entry was altered in a patient with a mononeuropathy: The exiting neural foramen was identified, and the needle tip was directed toward the site where the nerve root entered the plane between the anterior and middle scalene muscles. The course of the needle was expected to be lateral to the common carotid artery and internal jugular vein and posterior to the sternocleidomastoid muscle (Fig 1).

The distance from the skin site to the

plane between the anterior and middle scalene muscles was measured. The skin site was prepared and draped in sterile fashion. The superficial area overlying the insertion site was anesthetized with 1% lidocaine hydrochloride via a ½-inch 27-gauge needle. The deep tissues were anesthetized by using a ¾-inch 27-gauge needle, which was left in place and its position identified with CT. The needle was then replaced with a 20-gauge Chiba cutting needle (Manon Medical Products, Northbrook, Ill) and the tip advanced through the midportion of the anterior scalene muscle so it lay between the plane of the anterior and middle scalene muscles. The position of the needle was intermittently identified with CT (Fig 1).

The amount and type of local anesthetic to be injected depended on the clinical indication and was determined by the anesthesiologist present during the procedure. The local anesthetic was combined with iodinated contrast material (Omnipaque 300; Nycomed Amerisham, Princeton, NJ) with a dilution of 1 mL of contrast agent to 10 mL of local anesthetic. After the solution was administered, CT was performed to identify the distribution of the solution. Distribution between the anterior and middle scalene muscles indicated involvement of the supraclavicular plexus (Figs 1, 2).

The visual analog scale was used to assess pain relief following the CT-guided brachial plexus block. The visual analog scale is a linear scale that represents the range of pain a patient experiences. The scale usually is divided into centimeters and is 10 cm long. At each end of the scale, the descriptors often read "no pain" at the zero end and "the worst pain imaginable" at the 10 end. Patients can then draw a line through the scale at the level of pain they experience. To illustrate the results of therapy, a visual analog scale is commonly obtained before and after an intervention. The advantage of this type of measurement is simplicity and worldwide usage since it is not language dependent (9). In all five patients in our study, the visual analog scale was obtained both before and after treatment.

## I Results

A summary of our results appears in the Table. Four of the five patients experienced 75% or greater relief of pain following CT-guided nerve block. In the two patients with diagnostic block, 100% pain relief was experienced for the duration of the local anesthetic. Patient 4 ex-

perienced 50% pain reduction with the neurolytic brachial plexus block; in his case, other pain generators from diffuse metastatic disease could not be alleviated with the single procedure.

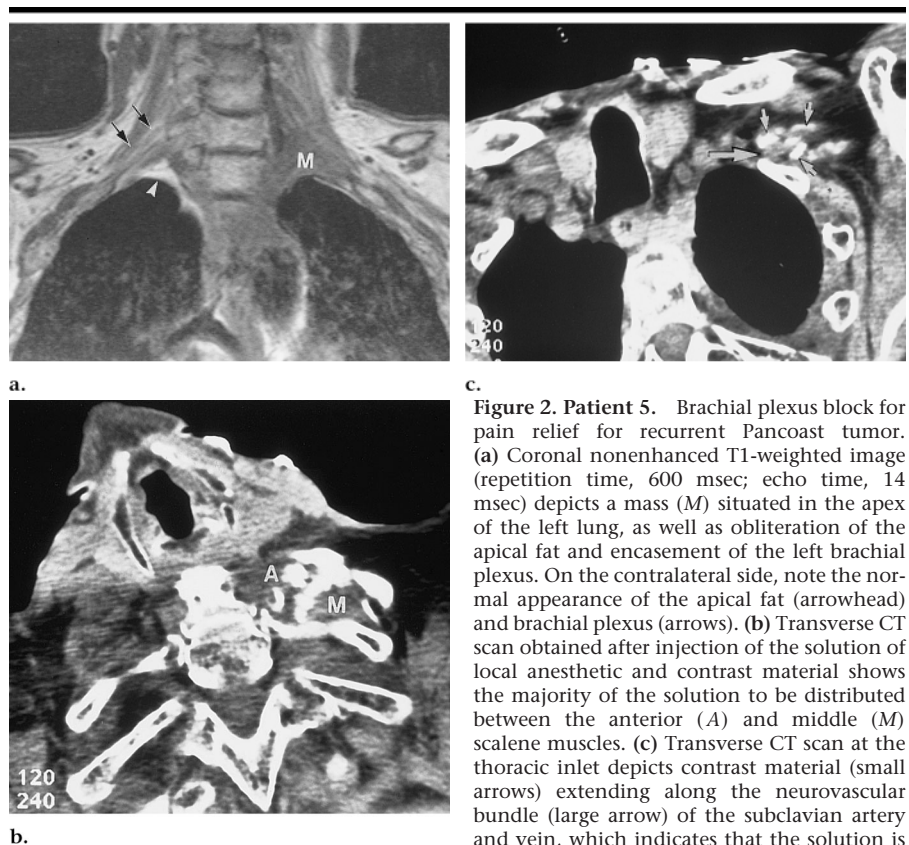
Two transient complications occurred. Patient 3 developed an ipsilateral Horner syndrome that resolved within 8 hours. Patient 5, with an extensive recurrent Pancoast tumor, developed a phrenic nerve palsy that necessitated overnight hospitalization due to oxygen saturation of less than 90% with 2 L of oxygen via a nasal cannula. The palsy resolved overnight, and the patient was discharged the next day without any further pulmonary compromise. The patient underwent repeat CT-guided brachial plexus block and experienced no complications.

## I Discussion

Brachial plexus nerve blocks are often used as regional anesthesia techniques that allow surgical procedures to be performed in the upper extremity. Peripheral nerve blocks obviate general anesthesia and are typically performed in patients who choose to be awake during the procedure or in outpatient surgeries (10); therefore, the potential complications associated with general anesthesia are avoided and earlier discharge from the recovery room and hospital are possible.

Four main approaches are used for percutaneous brachial plexus nerve blocks: interscalene, supraclavicular, infraclavicular, and axillary (8,10–16). The interscalene block is performed to anesthetize the brachial plexus as it courses between the anterior and middle scalene muscles and is used for surgical procedures involving the shoulder. The approach is based on palpation of the interscalene groove, which is situated posterior to the sternocleidomastoid muscle (11). It is hoped that the trajectory of insertion will introduce the needle into the brachial plexus along the plane between the anterior and middle scalene muscles (11,16–21) (Fig 4).

The approach of our imaging-guided technique is similar to that in the interscalene approach. The insertion site in both techniques is posterior to the sternocleidomastoid muscle (11). Our CT-guided approach, however, differs from that used for the standard interscalene block (11) (Figs 3, 4). In our technique, the needle enters the brachial plexus after it courses through the anterior scalene muscle. In the interscalene approach, however, the needle enters the brachial plexus along the plane between the an-



a.

b.

c.

**Figure 2.** Patient 5. Brachial plexus block for pain relief for recurrent Pancoast tumor. (a) Coronal nonenhanced T1-weighted image (repetition time, 600 msec; echo time, 14 msec) depicts a mass (M) situated in the apex of the left lung, as well as obliteration of the apical fat and encasement of the left brachial plexus. On the contralateral side, note the normal appearance of the apical fat (arrowhead) and brachial plexus (arrows). (b) Transverse CT scan obtained after injection of the solution of local anesthetic and contrast material shows the majority of the solution to be distributed between the anterior (A) and middle (M) scalene muscles. (c) Transverse CT scan at the thoracic inlet depicts contrast material (small arrows) extending along the neurovascular bundle (large arrow) of the subclavian artery and vein, which indicates that the solution is in contact with the brachial plexus. The patient experienced approximately 50% reduction in pain immediately after the injection.

terior and middle scalene muscles without piercing the anterior scalene muscle (11) (Figs 3, 4). We chose our anterior approach over the standard interscalene approach as it provides a more direct route that permitted the needle to be inserted in a trajectory perpendicular to the plane of the patient. In the interscalene approach, the trajectory of the needle is more parallel to the plane of the patient. We chose the anterior approach because it allows much easier control of needle placement during biopsies of the extracranial head and neck, in which the trajectory of the needle is perpendicular to the patient.

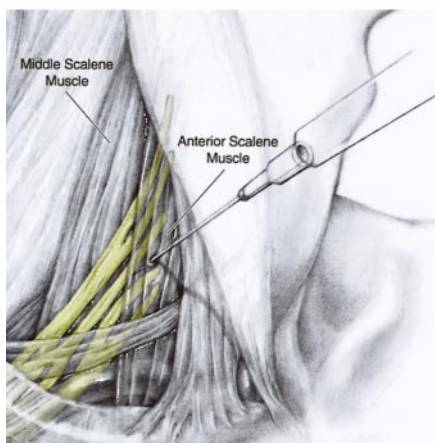
We have not performed the traditional interscalene approach with CT guidance, but it is an alternative. CT guidance could also be used for needle localization during supraclavicular and infraclavicular brachial plexus nerve blocks. In these approaches, however, the course of the needle is close to the lung apex. As a result, these approaches are associated with a higher frequency of pneumothorax than is the interscalene approach (8,18,21). Both the infraclavicular and axillary approaches are performed with 90° abduction of the arm. As a result, these procedures are difficult to perform in the CT gantry (8,18,21–24).

It is possible that interventional magnetic resonance units may be used for imaging guidance of supraclavicular, infraclavicular, and axillary approaches. The open gantry and multiplanar imaging capabilities may allow better visualization than that with CT for the various patient positions and oblique needle trajectories that are used routinely in these approaches. Ultrasonography (US) has also recently been described for imaging guidance of surgical anesthesia of the brachial plexus (25). In our study, we evaluated patients with chronic pain. US appears to be a viable alternative to CT for brachial plexus blocks in such patients, although Yang et al (25) state that the spread of solution should be documented with conventional radiography and the catheter position with CT. US guidance appears to be a reliable alternative in patients with normal muscular and fascial planes, but CT guidance may be preferred to US in patients with distorted anatomy due to neoplastic invasion or prior treatment. CT is also able to help localize therapy in patients with chronic mononeuropathies. It is not clear if US can be used to guide therapy in

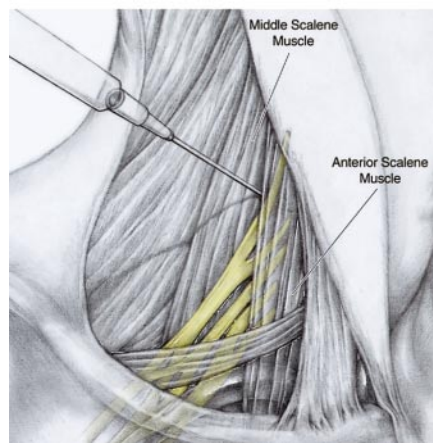
## Patient Data Summary

Patient No./ Age (y)/Sex	History	Reason for CT Guidance	Type of Procedure	Type of Analgesic and Volume	Reduction in Pain Based on Visual Analog Score	
					Pretreatment	Posttreatment
1/43/F	Left-sided postmastectomy syndrome	Distorted surface anatomy due to prior surgery and radiation therapy and possible neurolysis	Therapeutic brachial plexus block	20 mL 2% lidocaine hydrochloride, 4 mL 0.5% bupivacaine hydrochloride, 40 mg triamcinolone acetonide	9	2
2/33/M	Left C7 radiculopathy	Unsuccessful previous attempt with flouroscopy	Diagnostic C7 nerve block	2 mL 2% lidocaine hydrochloride	4	0
3/50/F	Left C7 radiculopathy	Unsuccessful previous attempt with flouroscopy	Diagnostic C7 nerve block	2 mL 2% lidocaine hydrochloride	7	0
4/63/M	Metastatic squamous cell carcinoma to left brachial plexus	Possible neurolysis	Neurolysis of brachial plexus	5 mL 12% phenol, 20 mL 0.25% bupivacaine hydrochloride	8	4
5/72/M*	Recurrent left-sided Pancoast tumor	Distorted surface anatomy due to prior radiation therapy	Therapeutic brachial plexus block	30 mL 0.25% bupivacaine hydrochloride, 40 mg triamcinolone acetonide	8	2

\* Patient underwent two therapeutic brachial plexus blocks on two separate occasions.



**Figure 3.** Schematic illustrates the approach used in the CT-guided procedure. The needle is inserted through the anterior scalene muscle. The tip is located in the plane between the anterior and middle scalene muscles, which denotes the location of the supraclavicular brachial plexus.



**Figure 4.** Schematic illustrates the traditional interscalene approach. The needle is inserted into the interscalene groove within the plane separating the anterior and middle scalene muscles. Compare this with the approach illustrated in Figure 3.

patients with mononeuropathies or is limited to use in only the brachial plexus.

We found no evidence that needle insertion directly into the brachial plexus can result in nerve injury. In fact, elicitation of paresthesia helps confirm proper needle location prior to the administration of analgesic when these techniques are performed without imaging guidance (8,18,19). Three of the five patients in our series experienced paresthesia during needle placement.

Our results suggest that the use of im-

aging guidance may reduce the risk of complications associated with brachial plexus nerve blocks performed with use of surface landmarks. The risk of complications is even higher in patients with landmarks that are not easily palpable (8,18). Complications commonly reported with percutaneous interscalene blocks with use of surface anatomic landmarks are Horner syndrome (70%–90%) and phrenic nerve palsy (40%–60%) (8,18,19). Complications in our series were phrenic nerve palsy (17%) and Hor-

ner syndrome (17%) in one patient each. Pneumothorax is reported in as many as 4% of patients (16). Malposition of the needle in the vascular structures of the neck may result in injection of local anesthetic into the jugular vein, carotid artery, or vertebral artery (15), which may result in laceration, dissection, hematoma, air embolism, seizures, apnea, or blindness. The addition of colloidal materials to local anesthetics for pain management may result in infarcts in the distribution of the vessel that has been inadvertently injected (15,17–20,22). A contrast material-enhanced CT study performed prior to needle insertion helps identification of the pertinent vascular structures that must be avoided.

Insertion of the needle into a subarachnoid, subdural, or epidural space has also been reported (8,10,17,18,20,22–24). Unintentional injection of local anesthetic in these areas may result in partial or complete spinal anesthesia (8,10,17,18,20,22–24). CT guidance during the procedure helps avoid needle insertion into the spinal canal and reduces the likelihood of intraspinal injection. Other complications reported are injury to the recurrent laryngeal and vagus nerves (15). The two complications in our series were likely due to spread of the analgesic to the adjacent nerves (sympathetic chain and phrenic nerve), because they were transient and resolved within the time expected in nerve blocks performed with use of surface landmarks.

Another potential advantage of CT guidance is a reduction in the amount of analgesic injected to achieve adequate pain relief. As much as 40 mL of local anesthetic is often recommended to achieve adequate pain relief for blocks that are performed without imaging guidance (8). With CT guidance, adequate pain relief was obtained with less than 20 mL of local anesthetic in most cases. The ability to visualize spread following administration allowed identification of the structures that came into contact with the analgesic (Figs 1, 2). Visualization of adequate distribution allowed use of a lower volume of analgesic and may have contributed to the low rate of Horner syndrome and phrenic nerve palsy in our series.

In summary, our initial results suggest that CT-guided brachial plexus block is a promising technique for the treatment of patients with intractable pain in whom normal surface landmarks cannot be palpated. Larger series must be studied before the benefits of performing these procedures with CT guidance as opposed to use of standard surface landmarks can be adequately determined.

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